

Test methods for hot dip galvanized coatings

Introduction This Japanese Industrial Standard has been prepared based on the second edition of **ISO 1460** *Metallic coatings—Hot dip galvanized coatings on ferrous materials—Gravimetric determination of the mass per unit area* published in 1992 with some modifications of the technical contents.

In this Standard, which specifies the test methods for hot dip galvanized coatings applied on steel products and steel work pieces, in addition to the coating mass test (indirect method) specified in the original International Standard, tests that **are not** specified in the original International Standard are also included. The added test methods are as follows: coating mass test (direct method) in 5.1, coating mass test (electromagnetic thickness test) in 5.3, cupric sulphate test in clause 6, adhesion test in clause 7 and property test (alkali solubility test) in clause 8.

In the clauses that are corresponding to the original International Standard, namely, 1 (Scope), 2 (Normative references), 3 (Terms and definitions), 4 (General) and 5.2 (Indirect method), the portions with continuous sidelines or dotted underlines are the matters in which the contents of the original International Standard have been modified. A list of modifications with explanations is given in Annex (informative).

1 Scope This Standard specifies the test methods for hot dip galvanized coatings (hereafter referred to as "coatings") applied on steel products and steel work pieces (hereafter referred to as "substrates").

NOTE : The International Standard corresponding to this Standard is as follows.

In addition, symbols which denote the degree of correspondence in the contents between the relevant International Standard and **JIS** are IDT (identical), MOD (modified) and NEQ (not equivalent) according to **ISO/IEC Guide 21**.

ISO 1460 :1992 *Metallic coatings—Hot dip galvanized coatings on ferrous materials—Gravimetric determination of the mass per unit area* (MOD)

2 Normative references The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. The most recent editions of the standards (including amendments) indicated below shall be applied.

JIS C 8305	<i>Rigid steel conduits</i>
JIS G 3442	<i>Galvanized steel pipes for ordinary piping</i>
JIS H 8501	<i>Methods of thickness test for metallic coatings</i>
JIS H 8641	<i>Hot dip galvanized coatings</i>
JIS K 1433	<i>Copper sulfate for industrial use</i>
JIS K 8422	<i>Copper (II) oxide</i>
JIS K 8574	<i>Potassium hydroxide</i>

JIS K 8576 *Sodium hydroxide*

JIS K 8847 *Hexamethylenetetramine*

JIS Z 0103 *Glossary of terms used in rust and corrosion preventive technology*

3 Terms and definitions For the purposes of this Standard, the terms and definitions in **JIS Z 0103** and the following apply.

- a) **substrate** steel product or steel work piece before hot dip galvanized coating is applied
- b) **product** substrate on which hot dip galvanized coatings have been applied
- c) **galvanized coating** hot dip galvanized coating layer, composed either of zinc or alloy of zinc and iron, which is formed on the substrate

It refers to the part from the galvanized surface to the surface of the substrate.

- d) **coating mass** mass of galvanized coating per unit area, which is expressed in grams per square metres, with the unit g/m^2

4 General matters

4.1 Relation to product standard Classification of test methods applied to the products, acceptability criteria of test and retest are specified in the respective product standards.

4.2 Classification of steel products and steel work pieces Steel products and steel work pieces shall be classified into the following five types according to their shapes.

- 1) **Pipes** Steel pipe for water supply, conduit, steel piping pipe, steel tubes for structural purposes, steel tubes for scaffolding and others
- 2) **Rolled steels** Rolled steels such as steel sheet, section, flat bar, steel bar and others
- 3) **Prefabricated steel products** Prefabricated steel products such as iron tower members, bridge members, steel frame members, metal fittings for shipbuilding, fine hardware, tank and others
- 4) **Bolts and nuts** Various kinds of bolts and nuts, washers and others
- 5) **Castings and forgings** Iron casting, steel forging, steel casting, pipe joint and others

4.3 Classification of test methods The test methods shall be classified into four types as shown in table 1, namely, coating mass test, cupric sulphate test, adhesion test and properties test.

Table 1 Classification of test methods

Classification of substrates	Test method							
	Coating mass test			Cupric sulphate test	Adhesion test			Properties test
	Direct method	Indirect method	Electromagnetic thickness test	Test	Visual inspection	Bending test	Hammer test	(Alkali solubility test)
Pipes	5.1	5.2	5.3	6	7.1	7.2	—	8
Rolled steels	5.1	5.2	5.3	6	7.1	—	7.3	—
Prefabricated steel products	5.1	5.2	5.3	6	7.1	—	7.3	—
Bolts and nuts	5.1	5.2	5.3	6	7.1	—	7.3	—
Castings and forgings	5.1	5.2	5.3	6	7.1	—	7.3	—

NOTE : Numbers given in the table indicate the clauses of the test items corresponding thereto.

5 Method for coating mass test

5.1 Direct method

5.1.1 Principle The coating mass is obtained by weighing the test piece before and after coating and calculating the increase in weight.

5.1.2 Test piece

a) **Sampling of test piece** According to the agreement between the purchaser and the supplier, the test piece shall be either:

- 1) the substrate itself;
- 2) cut off in a suitable size from the substrate to represent the product; or
- 3) in the case of the substrate whose surface area is difficult to determine, made into a similar shape using the same material.

5.1.3 Operation and calculation of coating mass After pickling, washing and drying the test piece as done for the substrate represented thereby, weigh it and carry out coating. Weigh it again and obtain the coating mass by dividing the increased amount by the surface area of the test piece.

5.2 Indirect method

5.2.1 Principle The hot dip galvanized coating is dissolved in hydrochloric acid and the resultant loss in mass is determined by weighing the test piece before and after the coating is dissolved.

5.2.2 Test piece

a) **Sampling of test piece** According to the agreement between the purchaser and the supplier, the test piece shall be either:

- 1) the product itself;
- 2) cut off from a coated product;
- 3) made by cutting a substrate representing the product in suitable size and coating it by the same method as that for the product unless the test piece can be cut off from the product.

b) **Sampling position and size of test piece**

- 1) **For pipes** One piece of tubular test piece about 60 mm in length shall be respectively taken, from both ends in accordance with a) 2). When the test piece is too large, it may be cut in a size suitable for measurement.
- 2) **For rolled steels and prefabricated steel products** The test piece shall be taken in accordance with 1), 2) or 3) of a), with a length of approximately 100 mm and in the case of a sheet, an area of approximately 100 mm x 100 mm.
- 3) **For bolts, nuts, castings and forgings** The test piece shall be taken in accordance with 1), 2) or 3) of a). Its screw thread part may be omitted.

5.2.3 Test solution Dissolve 3.5 g of hexamethylenetetramine specified in **JIS K 8847** in 500 ml of hydrochloric acid not less than 1.18 g/cm³ in density (35 %HClj". Dilute the solution with pure water to 1 L.

5.2.4 Cleaning of test piece The test piece shall be degreased with an organic solvent and dried if necessary. The organic solvent to be used shall be harmless to **the** coating.

5.2.5 Operation The test piece shall be weighed before zinc dissolves.

The accuracy shall be 1 % or under of the presumed coating mass (the prospective coating mass).

The quantity of the test solution shall be determined so as to be minimum 10 ml per 100 mm² of the surface area of the test piece. The test piece shall be dipped completely in the test solution at room temperature, and left until the coating film is completely dissolved. The progressive generation of hydrogen in the solution[^]) stops, which shows that the dissolution[^]) has completed. Then, rinse the test piece in running water, wipe it well with cotton cloth, dry it sufficiently, or immerse the test piece in alcohol and dry it immediately, and weigh the mass again with the accuracy specified in this subclause. After weighing, obtain the area S (mm²) with the accuracy of measurement of 1 % or under of the actual surface area.

Note (') The test solution may be repeatedly used as long as its coating layer can easily be removed.

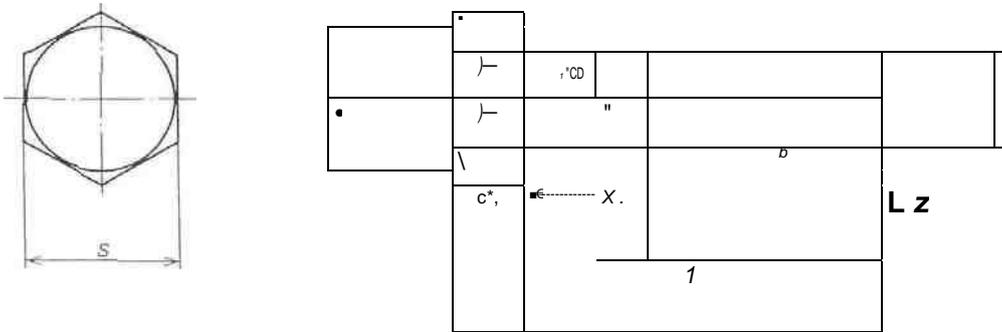
5.2.6 Calculation of coating mass The coating mass shall be calculated from the following formula:

- where,
- A : coating mass (g/m^2)
 - W_1 : mass of test piece before removing coating layer (g)
 - W_2 : mass of test piece after removing coating layer (g)
 - S : surface area of test piece (mm^2)

Further, the surface area S (mm^2) of test piece including screw thread part shall be calculated from the following formula. Furthermore, to respective numeral values used for calculation, nominal dimensions may be applied.

a) **Hexagon bolt (Metric screw thread)**

$$S = 1.95sd_k + 2A6sk - 0.87s^2 - 0.22d_s^2 + 3.14d_s[l - (b+x/2)] + 30d_s z - 30z^2 + (b-z + x/2)(5.27d_2 + 0.267p^2/d_2)$$

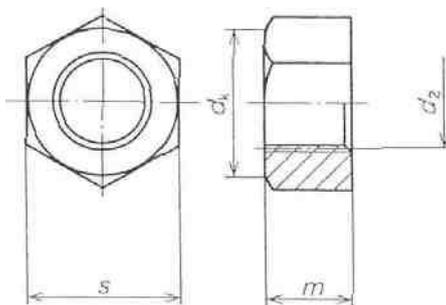


- S : surface area of coated parts of test piece (mm^2)
- s : width across flats (mm)
- k : height (mm)
- d_y : circular diameter of head (mm)
- d_s : shaft diameter (mm)
- I : underhead length (nominal length) (mm)
- b : thread length (mm)
- length of incomplete thread (mm)
- x : length of screw end (mm)
- z : pitch

d_z : pitch diameter (mm) **Figure 1**

Shape and dimensions of hexagon bolt (Metric screw thread) b) Hexagon nut (Metric screw thread)

$$S = 1.95sd^* + 3.46sm - 0.87s^2 - 0.22d_s^2 + m(5.19d_2 + 0.263p^2/d_2)$$



- S : surface area of coated parts of test piece (mm^2)
- s : width across flats (mm)
- m : height (mm)
- d_2 : pitch diameter (mm)
- d : circular diameter of head (mm)
- p : pitch

Figure 2 Shape and dimensions of hexagon nut (Metric screw thread)

- 1698 -

Note ⁽²⁾ When the concentration of the cupric sulfate solution is significantly reduced due to the excessively large dimension of the un-coated surface area, this part shall be coated with a suitable coating material.

6.3 Test solution Mix 100 ml of water per 36 g of copper sulfate for industrial use specified in **JIS K 1433**, dissolve by heating, and add to it excessive powdered copper (II) hydroxide [Cu(OH)₂] (for chemistry)⁽³⁾ ⁽⁴⁾ to neutralize free sulfuric acid, mix and leave it to stand for 24 h. Thereafter, filter and condition it at 18 °C to take the solution of 1.186 g/cm³ to 1.188 g/cm³ in density (measured with a hydrometer, etc.) as the test solution.

Notes ⁽³⁾ The amount of copper (II) hydroxide is about 10 g per 10 L of the solution. It is determined by the precipitation at the bottom of the vessel that the excessive amount of the cupric hydroxides exists.

⁽⁴⁾ About 8 g of copper (II) oxide specified in **JIS K 8422** in place of copper (II) hydroxide per 10 L of the solution may be used. In this case, it shall be left to stand for 48 h.

Alternatively, about 12 g of powder basic copper carbonate [CuCO₃-Cu(OH)₂] (for chemistry) per 10 L of the solution may be used. In this case, it shall be left to stand for 24 h.

6.4 Amount of test solution Not less than 6 ml of test solution per 1 cm² of its surface area shall be used so that the test piece is completely dipped therein and the same solution may be used until it is dipped 20 times.

6.5 Cleaning of test piece Shall be in accordance with **5.2.4**.

6.6 Operation A cleaned test piece shall be quietly immersed at the centre of the test solution kept at 16 °C to 20 °C for 1 min. When immersing the test piece, care shall be taken not to stir the solution or touch the wall of the vessel with the test piece.

The removed test piece shall be washed immediately in water and the copper adhered to the coating surface is wiped off with a brush or the like.

This operation shall be repeated.

6.7 Judgement of end point

6.7.1 Where becoming end point Where brilliant adherent metallic copper is deposited on the substrate of the coating.

6.7.2 Where not becoming end point

a) Where not corresponding to **6.7.1**.

b) The following cases in **6.7.1** do not become end point:

1) The case where the whole area deposited with brilliant adherent metallic copper does not reach 0.05 cm².

- 2) The case where the brilliant adherent metallic copper can be scraped off with dull tool such as the hack of the knife and coating layer appears under copper.

NOTE : When there is any question as to the presence/absence of a coating layer under adherent metallic copper, the adherent metallic copper shall be scraped off and one drop or several drops of dilute hydrochloric acid are dripped on the exposed position. The coating layer shall be judged to be present if there is an active generation of the hydrogen gas.

- 3) The case where the brilliant adherent metallic copper is deposited on the corner of the test piece or within 10 mm from its end.
- 4) The case where the brilliant metallic copper is deposited on the cut and scratched parts generated after the coating and the part adjacent thereto.

6.8 Acceptability judgement The case where the operation of 6.6 is carried out for the number of times specified in table 2 of JIS H 8641 and the end point is not reached, shall be acceptable.

7 Methods for adhesion test

7.1 Method by visual inspection^(A) The presence of cracks or exfoliation of the coating layer due to the ordinary handling shall be examined.

Note (6) The visual inspection method shall be applied to products which are not subject to the hammer test or bending test.

7.2 Bending test⁽⁸⁾ When bent by a specified angle with an inner side radius of specified times the diameter or thickness of the test piece, the surface condition of the coating layer such as the bent part or welded part shall be examined.

Note ^(B) The bending test shall be applied to JIS G 3442 and JIS C 8305.

7.3 Hammer test The surface condition of the coating layer which has been subjected to hammer blows shall be examined. This test shall be applied in the cases where the test piece as specified in 7.3.1 can be obtained.

7.3.1 Test piece The test piece shall be 40 mm min. x 40 mm min. x 8 mm min. (thickness), and the surface shall be flat and smooth.

7.3.2 Apparatus for hammer test The apparatus for the hammer test is given in figure 3.

7.3.3 Setting of test piece The test piece shall be horizontally fixed so as not to be moved easily with a blow of the hammer, and the test surface shall be perpendicular to the hammer.

7.3.4 Operation The test surface shall be horizontal and the hammer shall be allowed to fall freely from the position where its arm is vertical centring the support table. Blows shall be applied to 5 parallel positions at 4 mm intervals and the exfoliation

and embossment between their traces shall be examined. The area within 10 mm from the corner or end shall not be tested. Each position shall be stuck only once.

This test shall be carried out at an ordinary temperature.

Unit: mm

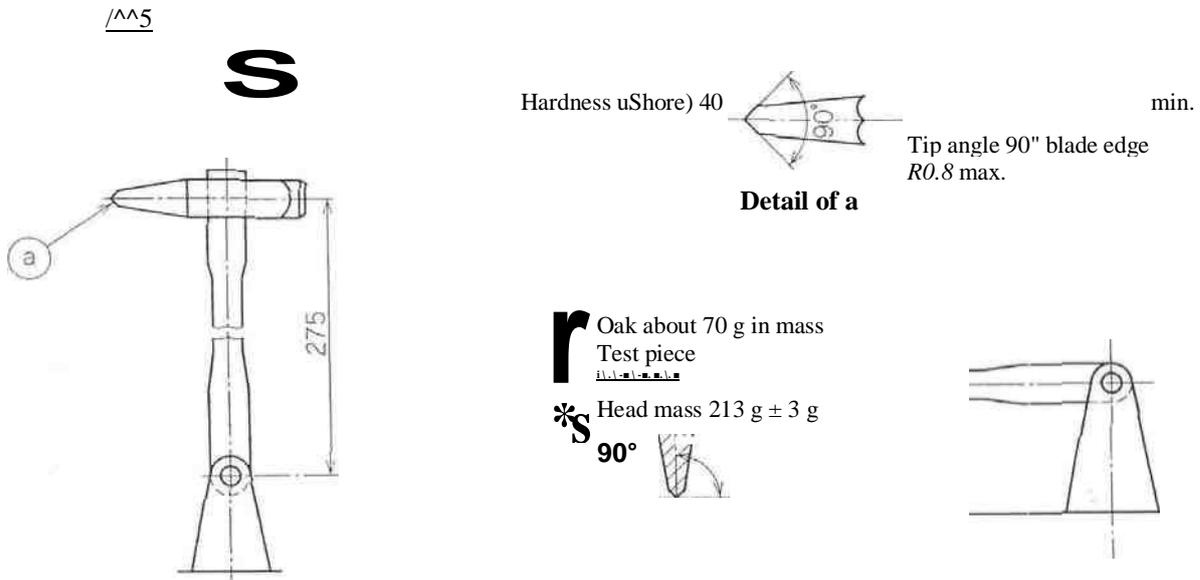


Figure 3 Apparatus for hammer test

7.4 Acceptability judgement The acceptability judgement for the adhesion test shall be as follows.

- a) As a result of the adhesion test by visual inspection, coating layers on which no cracking or exfoliation is observed shall be deemed acceptable.
- b) As a result of the bending test, coating layers on which no embossment or exfoliation is observed shall be deemed acceptable.
- c) As a result of the hammer test, coating layers on which no exfoliation or embossment is observed between the dents shall be deemed acceptable.

8 Method for properties test⁽⁷⁾ (alkali solubility test)

Note ⁽⁷⁾ The properties test shall be applied to **JIS G 3442**.

8.1 Test piece The product as it is shall be used as the test, piece and its shape and dimensions shall conform to table 2.

Table 2 Shape and dimensions of test piece

Nominal diameter of pipe	A	10	15	20	25	32	40
	B	%	V_2	$3/4$	1	$IV <$	$I/2$
Length of test piece (mm)		30	30	30	30	30	30
Shape of section		Whole circle	Whole circle	Whole circle	$1/2$ circle	$1/2$ circle	V_i circle

Nominal diameter of pipe	A	50	65	80	90	100	125
	B	2	$2V_2$	3	$3V_2$	4	5
Length of test piece (mm)		30	30	30	30	30	30
Shape of section		V_i circle	V_i circle	V_{fe} circle	V_{fe} circle	V_{fi} circle	V_{fi} circle

Nominal diameter of pipe	A	150	175	200	225	250	300
	B	6	7	8	9	10	12
Length of test piece (mm)		30	30	30	30	30	30
Shape of section		V_g circle	V_s circle	V_s circle	V_g circle	V_s circle	V_s circle

8.2 Test solution The test solution shall be prepared by dissolving 20 g of sodium hydroxide (reagent) specified in **JIS K 8576** or 28 g of potassium hydroxide (reagent) specified in **JIS K 8574** in 100 ml of water.

8.3 Cleaning of test piece The test piece shall be cleaned in accordance with **5.2.4**.

8.4 Operation The amount of the test solution shall be 5 ml min. per cm^2 of coating area, which can completely dip the test piece, and the temperature of the test solution shall be kept at 75 °C to 80 °C.

When the test piece is placed in the solution, the coating layer dissolves with the passage of time. While the zinc layer on the surface is dissolving, only a small amount of bubbles is generated, but once the alloy layer of zinc and iron is exposed, the generation of hydrogen becomes vigorous, filling the inside of the glass vessel with bubbles. When the substrate surface is exposed, the reaction becomes moderate and finally the generation of bubbles stops. This point being the end point, the elapse of time from the placement of the test piece shall be recorded.

Further, the cross section of the test piece may be protected with a suitable coating material so that the substrate surface is not directly in contact with the test solution.

8.5 Acceptability judgement The test shall be preferably accepted if the time from placement of the test piece to the end point is not less than 100 min.

- H 0401 -

9 Test report The following information shall be included in the test report.

- a) Title or number of the standard used
- b) Test item
- c) Shape, dimensions and/or surface area of test piece
- d) Test results
- e) Matters to be agreed between the purchaser and the supplier

Annex (informative) Comparison table between JIS and corresponding International Standard

JIS H 0401:2007 <i>Test methods for hot dip galvanized coatings</i>				ISO 1460:1992 <i>Metallic coatings—Hot dip galvanized coatings on ferrous materials—Gravimetric de-termination of the mass per unit area</i>			
(I) Requirements in JIS		(II) Inter- national Standard number	(III) Requirements in Inter- national Standard		(IV) Classification and details of technical deviation between JIS and the International Standard by clause Location of deviation: text Indication method: continuous sidelines or dotted underlines		(V) Justification for the technical deviation and future measures
Clause	Content		Clause	Content	Classifi- cation by clause	Detail of technical deviation	
1	Scope	ISO 1460	1	Specifies a method of determining the mass per unit area of hot dip galvanized coatings on ferrous materials.	MOD/ alteration	JIS limits the object of test to the hot dip galvanized coatings. JIS specifies also the different test method in addition to the test methods in ISO standard.	It is caused by the difference of system between ISO standard and JIS . The necessary test methods for evaluating the quality of hot dip galvanized coatings are added.
2	Normative references	ISO 1460	—	—	MOD/ addition	No normative reference in ISO standard.	Standards related to the additional test methods are cited.
3	Terms and definitions	ISO 1460		~	MOD/ addition	No definitions of terms in ISO standard.	The terms necessary for JIS are defined.

(I) Requirements in JIS		(II) International Standard number	(III) Requirements in International Standard		(IV) Classification and details of technical deviation between JIS and the International Standard by clause Location of deviation: text Indication method: continuous sidelines or dotted underlines		(V) Justification for the technical deviation and future measures
Clause	Content		Clause	Content	Classification by clause	Detail of technical deviation	
4 General matters	4.1 Relation to product standard 4.2 Classification of steel products and steel work pieces 4.3 Classification of test methods	ISO 1460			MOD/ addition	No specification in ISO standard.	The specifications necessary for JIS are added.
5 Method for coating mass test 5.1 Direct method	Specifies the measuring method for coating mass according to direct method.	—	—	—	MOD/ addition	—	It is the necessary test. The addition of this test is to be proposed to the International Standard ISO 1461 of hot dip galvanized coatings.
5.2 Indirect method	5.2.2 Test piece a) The sampling method for test piece shall be subjected to the agreement between the purchaser and the supplier. b) Specifies the sampling position and size of test piece.	ISO 1460	4		MOD/ addition	JIS specifies the sampling position and size according to the classification of the steel workpieces.	The sampling of test piece is specified because it is an important item. The proposal of this addition is to be submitted to ISO .

(I) Requirements in JIS		(II) International Standard number	(III) Requirements in International Standard		(IV) Classification and details of technical deviation between JIS and the International Standard by clause Location of deviation: text Indication method: continuous sidelines or dotted underlines		(V) Justification for the technical deviation and future measures
Clause	Content		Clause	Content	Classification by clause	Detail of technical deviation	
5.2 Indirect method (concluded)	5.2.3 Test solution		3		IDT	—	—
	5.2.4 Cleaning of test piece		5		MOD/addition	The calculation formula for coating mass is the same, however JIS specifies the calculation formula of surface area used for the calculation of hexagon bolt and nut.	The calculation for surface area of bolts and nuts is an important item, so it is specified. The proposal of this addition is to be submitted to ISO .
	5.2.5 Operation and calculation of coating mass		6				
			6 7		MOD/deletion		The domestic data in Japan is verified, and the addition will be proposed at the time of next revision of ISO .
5.3 Electro-magnetic thickness test	In accordance with JIS H 8501 .				MOD/addition		ISO 2178 specifies this electromagnetic test method for thickness, and JIS H 8501 is prepared on the basis of this ISO standard.
6 Cupric sulphate test	Specifies the method for cupric sulphate test.				MOD/addition		It is necessary for the measuring method for minimum coating thickness and the addition of this test to ISO 1461 is going to be proposed.

(I) Requirements in JIS		(II) International Standard number	(III) Requirements in International Standard		(IV) Classification and details of technical deviation between JIS and the International Standard by clause Location of deviation: text Indication method: continuous sidelines or dotted underlines		(V) Justification for the technical deviation and future measures
Clause	Content		Clause	Content	Classification by clause	Detail of technical deviation	
7 Methods for adhesion test	Specifies the method for adhesion test by visual observation, bending test and hammer test.				MOD/addition		It is necessary for the evaluation method for adhesion, and the addition of this test to ISO 1461 is going to be proposed.
8 Method for properties test	Specifies the method for properties test to be carried out on the galvanized steel tubes for water service.				MOD/addition		It is the necessary test for confirming the properties of galvanized steel tubes for water service.
9 Test report	Specifies the items to be mentioned in test report.		7	Test report	MOD/addition	ISO specifies the calculation method for surface area and coating mass. JIS specifies also the different test result.	The necessary items for JIS are added.

Designated degree of correspondence between JIS and International Standard: MOD

NOTES 1 Symbols in sub-columns of classification by clause in the above table indicate as follows:

- IDT: identical in technical contents.
- MOD/deletion: Deletes specification item(s) or content(s) of International Standard.
- MOD/addition: Adds the specification item(s) or content(s) which are not included in International Standard.
- MOD/alteration: Alters the specification content(s) which are included in International Standard.

2 Symbol in column of designated degree of correspondence between JIS and International Standard in the above table indicates as follows:

- MOD: Modifies International Standard.